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Research Article

Ergonomic Evaluation of Maize Sheller cum Dehusker

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Abstract

Maize is one of the most versatile emerging crops with wider adaptability under varied agro-climatic conditions. Shelling and dehusking are important post-harvest operations in the production of maize. Now various manufacturers are manufacturing separate machines for these two operations or single machine handling both the operations. In India these machines are manufactured by small artisans and little attention is paid on their ergonomic design. This paper presents an ergonomic evaluation of one of the commonly used maize sheller cum dehusker machine in Maharashtra state. Various key postures of the workers are analyzed and evaluated the risk during the poster. Also study gave the suggestions for the improvement. Tools like digital human manikin (DHM) and Rapid Upper Limb Assessment (RULA) are used in this study.

Keywords: *DHM, ergonomic analysis, farm equipment, Maize sheller-dehusker, RULA.*

1. Introduction

Maize is a major cereal crop grown throughout the world for both human and livestock consumption. It is cropped in about 160 countries having a wider diversity of soil, climate, biodiversity and management practices. It is the third most important food crops after rice and wheat in India especially cultivated in kharif season. Maize contributes nearly 9 % in the India's food basket. Maize is a basic ingredient to thousands of industrial products such as oil, starch, protein, food sweeteners, alcoholic beverages, pharmaceutical, textile, gum, cosmetic, film, package and paper industries etc. In Maharashtra, agriculture takes care of about 55 per cent of the population for its livelihood constituting the single largest provider of employment to the rural people of the state (Desai *et al*, 2012).

The scientists and engineers are developing equipments suitable to post harvest processing machines to make operations easy and fast on the farm to reduce the cost incurred, losses occurred and musculoskeletal disorders and to improve the efficiency and economic conditions of farming community (*Kumar et al*, 2002; Singh *et al*, 2010; Ghugare *et al*, 1991; Grandjean, 1988; Meyers, 1995; Bhuse and Vyavahare, 2014; Yadav and Pund, 2007).

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2. Methodology

The study is divided into four parts. The first part involved study of various thresher machines. The second part involved visiting premises to understand sheller cum dehusker machine operation and knowing the process. Video recording and photographs were taken from the working environment. In the third part of the study, the existing workplace was modeled with various postures taken by the operator during operation of the sheller cum dehusker machine using CATIA software. In this phase DHM and thresher cum dehusker models were developed. The last fourth part involved ergonomic analysis of the existing workplace for possible postures attained by operators or workers during the operation of the machine and provided suggestions for improvement (Bloswick, 1990; Sanjog *et al*, 2012; Somasundaram & Srinivasan, 2010).

2.1 Anthropometric dimensions

Ergonomic analysis of maize sheller cum dehusker was performed for both 5th and 95th percentile male operators (Vyavahare and Kallurkar, 2012). Values of anthropometric parameters (mean & standard deviation) considered for the study for male agricultural worker are shown in table 1.

Table 1 Anthropometric parameters of male agricultural workers of Maharashtra state

Sr. No.	Description	CATIA ref. no.	Values (cm)	
			Mean Value	SD
1.	Stature	us100	164.7	6.0
2.	Acromial Height, Standing	us3	137.6	5.5
3.	Acromion Radiale Length	us5	31.6	2.6
4.	Biacromial Breadth	us11	32.9	1.9
5.	Radiale Stylion Length	us88	26.5	2.3
6.	Sleeve Length Outseam	us98	59.5	3.3
7.	Shoulder-Elbow Length	us92	37.0	2.6
8.	Forearm Hand Length	us55	45.4	2.9
9.	Hand Length	us60	18.0	0.9
10.	Wrist-Index Finger Length	us130	16.7	0.9
11.	Hand Breadth at Metacarpal-III	us58	8.1	0.4

Fig. 1 Maize sheller cum dehusker (a) Actual machine (b) 3D model

2.2 Sheller cum dehusker machine and manikin modeling

There are various sheller cum dehusker machines available in the market. Commonly used one was selected for the study and modeled in CATIA V5R17 (Fig. 1). First, all the parts of the machine are modeled and then assembled in assembly workbench. The manikin was modeled using CATIA's human builder module using various anthropometric dimensions. Using human measurements editor workbench, dimensions of Maharashtra workers as shown in table 1 were updated. Workers working here on machine are divided into two categories-Operator, who feeds the corns in the hopper and supporting worker(s), who supplys buckets or bags to the operator.

2.3 RULA analysis

RULA allows manikin's upper limbs analysis based on parameters such as distance, weight and frequency. It is used to canvas many aspects of manikin posture based on various variables and user data, such as lifting distance, lowering distance, auction duration, object weight and task frequency. It takes care of work specific variables such as external support to the manikin, the balance of the manikin and orientation of arms of the manikin with reference to the body and feet. RULA score depicts acceptability of the task and posture and gives suggestions whether task or posture is acceptable or should be investigated further or should be changed soon or immediately. Hence, the RULA analysis helps to optimize manikin posture resulting in better designed and widely accepted products and workplaces (Ren & Xiao, 2009; Sanjog *et al*, 2012). Karandikar and Sane (2014) used these RULA scores to arrive at Job Difficulty Index (JDI). RULA analysis was performed for seven commonly attained postures by operator (Fig. 2 & 3). It is observed that buckets or bags are used for handling of corns by the workers/operators. Fig. 2 shows three postures attained by the operator using buckets for carrying the corns. Fig. 3 gives postures attained while using bags.

Fig. 2 Postures attained by an operator with buckets (a) Posture 1 (b) Posture 2 (c) Posture 3

Fig. 3 Postures attained by an operator with bag (a) Posture 4 b) Posture 5 c) Posture 6 d) Posture 7 e) Posture 8

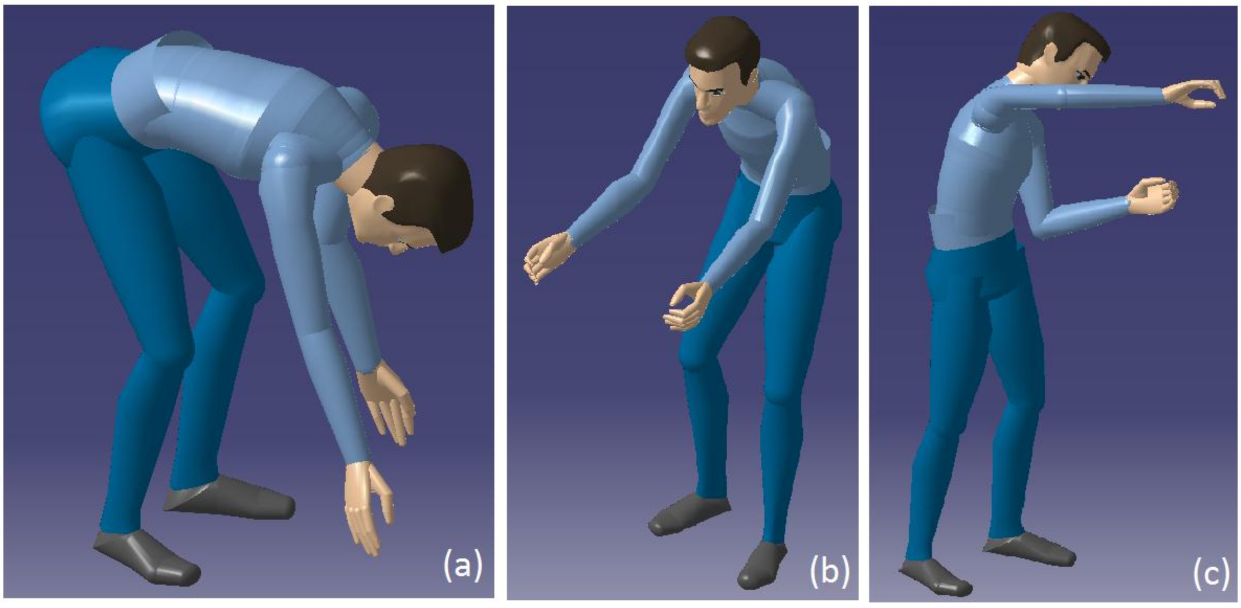

Fig. 4 Modeled postures attained by an operator with buckets (a) Posture 1 (b) Posture 2 (c) Posture 3

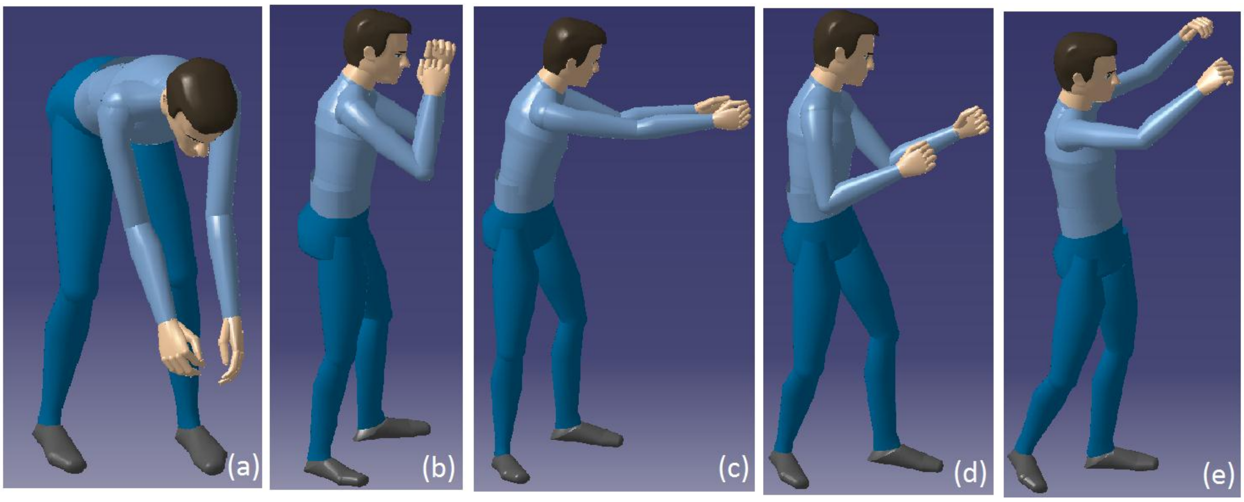

Fig. 5 Modeled postures attained by an operator with bag (a) Posture 4 b) Posture 5 c) Posture 6 d) Posture 7 e) Posture 8

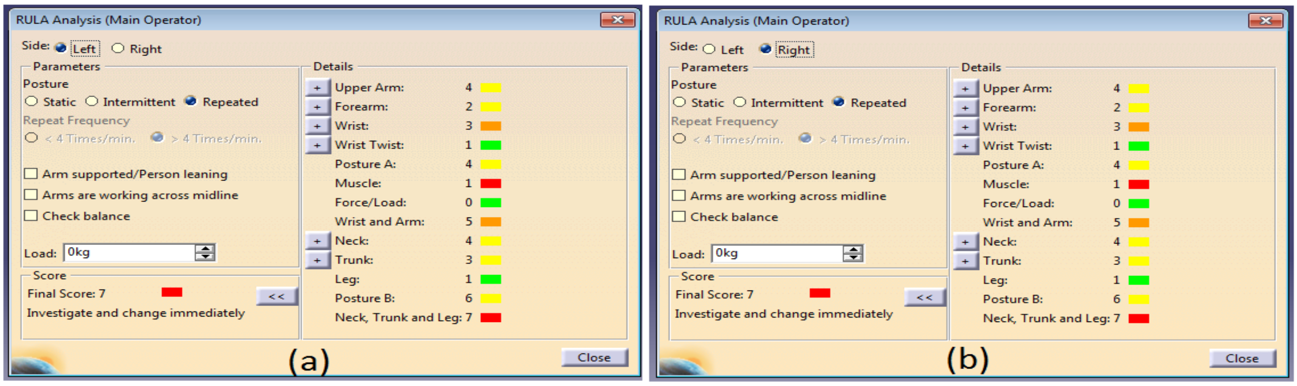

Fig. 9 RULA analysis window (a) for left side of body (b) for right side of body

Table 2 Interpretation of RULA score in basic mode

Score	Color	Meaning
1 and 2	Green	The posture is acceptable if it is not retained or repeated for longer period
3 and 4	Yellow	Further investigation is required and changes may also be required.
5 and 6	Orange	Investigation and changes are needed soon.
7	Red	Investigation and changes are needed immediately.

Fig. 4 and 5 show the corresponding postures modeled using DHM technique. At most care was taken to model the posture as operator attains during work.

2.4 Interpretation of RULA score

The RULA analysis examines the risk factors like the number of movements, working posture, static muscle work force and working time without a break to provide a final score ranging from 1 to 7. The final score is accompanied by a colored zone changing from green to red on the basis of the final score. The score report consists of two modes, namely basic modes and advanced or detailed mode. The scores, colors and their meaning in the basic mode are shown in table 2.

2.5 Reach analysis

Reach analysis is generally performed to access reach of the worker at all the locations in the work environment and also to check the access of the worker to rotating parts which may cause injury to the operator (fig. 7 and 8). In the present study reach analysis is carried out to check whether the worker's hand can reach to the rotor in the drum of maize sheller cum dehusker. The reach analysis shows that 5 percentile population worker's hands cannot reach the rotor in the drum, but 95 percentile population worker's hand reaches the rotor. Hence machine is not safe and may cause injury to the worker.

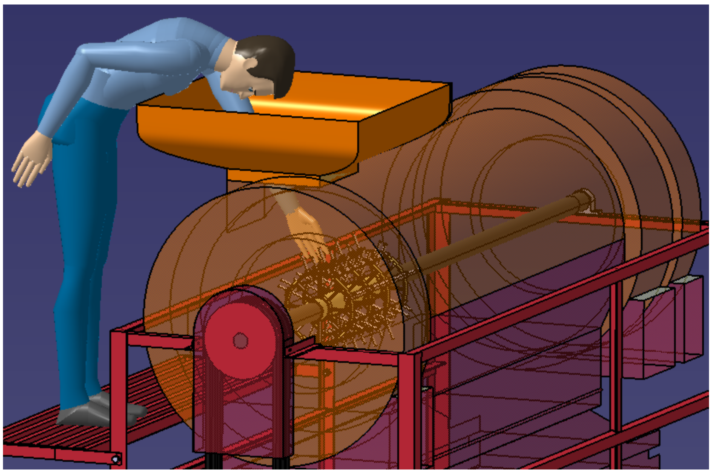

Fig. 7 Reach analysis for 95th percentile operator

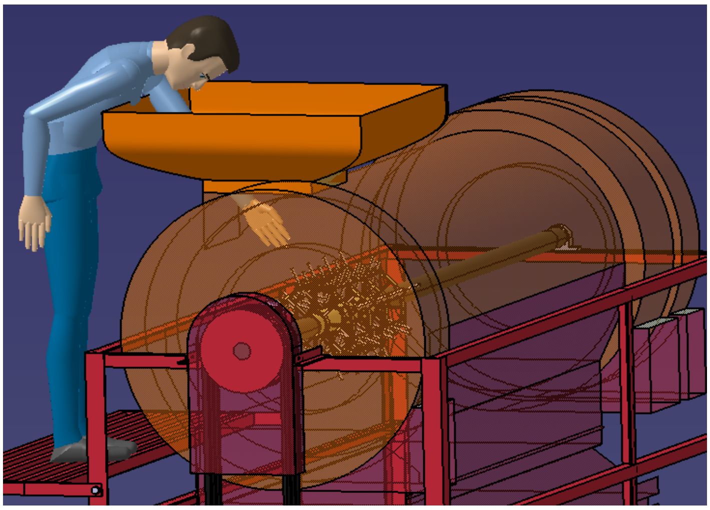

Fig. 8 Reach analysis for 5th percentile operator

3. Results and discussion

Detailed RULA analysis window for left side & right side for posture 1 is shown in Fig. 9. Table 3 presents RULA score for all the seven postures considered in this study.

In majority of the postures considered in this study, the operator is required to squat, forward/lateral bend or flex/extend hands, twist the wrist/spine etc. In posture 1, operator takes squatting position along with bending. In posture 2, operator bends forward with upper arms flexed and forearms extended. Posture 3 consists of abduction & flexion of right upper arm and flexion of the forearm. In this posture, left upper arm is in abduction and forearm in flexion with lateral bending of the spine and head. Posture 4 consists of forward bending with upper arms flexed and forearms extended. Posture 5 contains, flexion of upper and fore arms with the load in hands. Posture 6, consists of flexion of upper arms with forearms extended. Posture 7 and 8 contain flexion of upper and fore arms and abduction of upper arms with little load on hands as most of the corns are already transferred to hopper from the bag.

Table 3 RULA score for key postures of the operator while operating maize sheller cum dehusker

Posture	RULA Score (Left side)	RULA Score (Right side)
1	7	7
2	7	7
3	7	7
4	7	7
5	7	7
6	6	7
7	7	7
8	7	7

The RULA analysis (table 3) shows that existing working postures 1 to 8 of the operator are highly dangerous (score 6 & 7) and must be changed by in-depth investigation of workstation in order to keep away the worker from musculoskeletal disorders.

Machine hopper and operator standing platform height is more, which forces the operator to bend to collect a bucket or bag from supporting worker and raise the hands to feed the corns to the hopper. There is a limitation in decreasing the hopper height, but the platform can be raised and its distance from the hopper can be reduced to avoid raising of hands while corn feeding. Also, some means can be provided to raise the height to which the bucket or bag is given into the hands of operator such as providing an elevated platform to the supporting operator.

The study also reveals that the capacity of the machine is 4500 to 6000kg/hour of finished grains, which requires large quantities of corns to be fed. This supply of corns is very difficult to meet manually. As the machine is operated by tractor, whose capacity is more and remains unutilized, it is advisable to develop a low cost feed mechanism wherein little human intervention is required such as conveyor. This will reduce the drudgery caused and cost of operation.

In order to prevent the reach of operator hand to the rotor, hopper can be modified as shown in Fig. 7. In this design, direct access of the hand to the rotor is restricted.

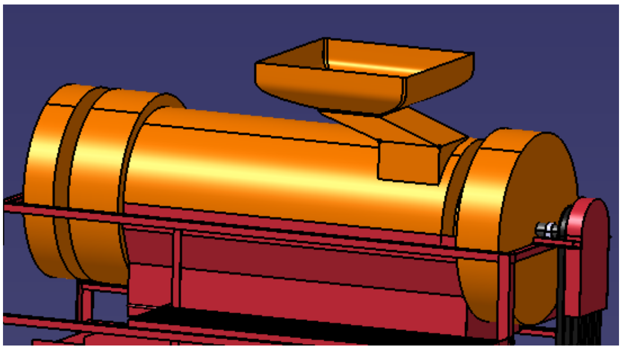

Fig.7 Modified Hopper

Conclusions

Thus, DHM technique can be successfully used to develop the ergonomically sound products based on anthropometric data of user population. Moreover the use of a virtual model of the product for the analysis purpose reduces cost of the development of the product. Also reach and fit of the operator to the product can also be checked easily. Further, various postures that are demanded by particular operation can be simulated virtually for detailed analysis of the workstation. The ergonomically designed machines/equipments can reduce drudgery, increase efficiency, safety and comfort.

References

A. Kumar, D. Mohan, R. Patel, M. Varghese, (2002), Development of grain threshers based on ergonomic design criteria. *Applied Ergonomics,* 33, 503–508.

A. Singh, U. S. Gautam, S. Pannase, A. Singh, (2010), Ergonomic evaluation of farm women during maize shelling. *Indian Res. J. Ext. Edu,* vol. 10, no. 3, pp. 41-44.

A. Somasundaram, P. Srinivasan, (2010), Design optimization of dosa making workstation for smooth ergonomic interface. *Journal of Scientific & Industrial Research*, 69, 221-224.

B. D. Ghugare, S.H. Adhaoo, L.P. Gite, A. C. Pandya, S. L. Patel, (1991), Ergonomic evaluation of a lever-operated knapsack sprayer. *Applied Ergonomics,* vol. 22, no. 4, pp. 241-250.

D., Bloswick, (1990), An ergonomic analysis of the ladder climbing activity. *International Journal of Industrial Ergonomics*, 6, 17-27.

E. Grandjean, (1988), *Fitting the task to the man.* London: Taylor and Francis.

J. Meyers, (1995), Using ergonomics in the prevention of musculoskeletal cumulative trauma injuries in agriculture: Learning from the mistakes of others. *Journal of Agromedicine,* vol. 2, no. 3, pp. 11-24.

J. Ren, D. Xiao, (2009), Ergonomic simulation and evaluation of elliptical trainer with CATIA V5. *CADDM*, vol. 19, no. 1, pp. 81-86.

J. Sanjog, H. Karmakar, C. Agarwal, D. Patil, (2012), Designing and ergonomic evaluation of a shoe-rack in CAD environment. *International Journal of Computer Applications*, vol. 49, no. 20, pp. 38-41.

M. D. Desai, N. Biradar, L. Manjunath, M. T. Doddamani, J. A. Mulla, P. A. Katarak (2012). Livelihood profile of farmers in western region of Maharashtra. *Karnataka J. Agric. Sci.*, vol. 25, no. 2, pp. 217-220.

P. K. Bhuse, R. T. Vyavahare, (2014), Ergonomic Evaluation of Knapsack Sprayer used in Agricultural Application. *International Journal of Scientific & Engineering Research*. Vol. 5, no. 12, pp. 903-907.

R. T. Vyavahare, S. P. Kallurkar, (2012). Anthropometric and strength data of Indian agricultural workers for equipment design: a review. *Agric Eng Int: CIGR Journal*, vol. 14, no. 4, pp. 102-114.

R. Yadav, S. Pund, (2007). Development and ergonomic evaluation of manual weeder. *Agric Eng Int: CIGR Journal*. 9, Manuscript PM 07 022.

V. N. Karandikar, S. M. Sane, (2014), Application of Job Difficulty Index© to compare work severity using P-SVR© method of Ergonomic analysis. International Journal of Current Engineering and Technology, vol.4, no.1, 417-422.